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XTE OBSERVATIONS OF THE INTRADAY VARIABLE BL LAC S5 0716+714 IN A COORDINATED MULTIWAVELENGTH STUDY

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S5 0716+714 was observed with the Rossi X-ray Timing Explorer (RXTE) between 1996 April 06 and 1996 April 22 as part of a multifrequency monitoring campaign for this source observed to show extreme intra-day variability (IDV) at a number of frequencies. There were 24 distinct epochs of observation ('views') with the RXTE Proportional Counter Array (PCA), each lasting on average 3–4 ks. There were a number of technical problems with the data. During view 10 no Proportional Counter Unit (PCU) was on. A gain change (from gain epoch 2 to gain epoch 3) took place during view 11, on 1996 April 15. No data were received for view 18. Views 10, 11 and 18 have been omitted from our analysis. There were two distinct pointings of the telescope in views 4 and 17 (all the other observations have only one pointing), and in many of the pointings the data are broken by periods where the high voltage was turned off during South Atlantic Anomaly (SAA) passages and Earth occultations. Originally no filter file was available for views 21 and 22, and for the second pointing of view 17, because housekeeping data were missing, but these data were supplied when the observations were reprocessed in early 1998. For most of the remaining observations only 3 PCUs were on; the exceptions are views 23, 24 (4 PCUs) and 17, 19, 20, 21 and 22 (5 PCUs). All working PCUs have been analyzed. The third part of the first pointing of view 17 was found to be very short and is discarded from our analysis. The second part of observation 2 is pointed far off-axis and is discarded.

Our analysis of the data has yielded different results over time, reflecting the different tools available for background estimation. Our first analysis, at the GSFC Guest Observer Facility in November 1996, revealed many problems with the preliminary background models available at that time. In early 1997 we re-analyzed the data using the then-available Q6 models (which estimate the particle background on the basis of 6 coincident discriminators) together with an activation model (in which the expected particle background is allowed to vary on the basis of spacecraft co-ordinates, particularly with respect to the SAA passage), and cosmic X-ray background models (based on blank-sky observations). Our results appear in Otterbein et al. (1998).

We then switched to using the VLE (very large event) models for gain epoch 3 data. These are based on observations rather than simulations, and they use the very large event discriminators in the PCUs. These were thought to be better than the Q6 models, but could only be applied to our gain epoch 3 data because of a shortage of necessary observations on which to pin the models during gain epoch 2. Our results based on using the Q6 models for our gain epoch 2 data, and the VLE models for our gain epoch 3 data, appear in Otterbein et al. (1999). The poor correspondence between day-to-day variability in the RXTE and ROSAT HRI bands was a cause of lingering concern.

L7/240 background models then became available. They are based on count rates which take direct account of activation (using 7 rates from adjacent anodes, hence L7) and a separate component with a 240-min half-life, based on signals from the High Energy X-ray Timing Experiment (HEXTE) particle monitor, to model the slowly-varying component of the activation. The models are applicable to faint sources (< 40 counts s^{-1} PCU^{-1}), but initially were available only for gain epoch 3. Their use led us to believe that the apparent positive trend seen in the intensity of the source with time using data analyzed with the Q6 background models (Otterbein et al. 1998) is plausibly an effect of crossing the gain epoch.

During the last year, L7/240 background models for gain epoch 2 have become available, and we have finally been able to use the same procedures to produce backgrounds for all the 'views'. The new backgrounds bring the epoch 2 and 3 datasets into better agreement. The attached figure shows the count rates as a function of time using the L7/240 models for both gain epochs. The gain change occurs around day 189, and we see that although the count rates are now slightly higher in gain epoch 2, the difference is not significant.

Assuming that the analysis using the L7/240 models is the best, the other models appear to have seriously underestimated the background. The average count rate in the L7/240 models in gain epoch 3 (where the background is best determined) is about 0.34 counts s^{-1} with 3 PCUs; earlier background subtraction gave count rates of 1 s^{-1} or higher. The estimated systematic error on the L7/240 models is about 0.15 counts s^{-1} in the 2-10 keV energy range (for 3 PCUs), a figure determined by analysis of blank sky observations at Goddard; see <URL: http://lheawww.gsfc.nasa.gov/users/keith/pcabackgd_mins/minutes.981022> for more information. However, the 1σ cosmic X-ray background fluctuation across the sky is about 0.7 counts $^{-1}$ for 3 PCUs at this energy range, so the measured count rates are insufficient to claim a detection. After fixing the baselines of the blank-sky and S5 0716+714 data at the same level, there is no significant difference on a Kolmogorov-Smirnov test between the 'variability' in our data and that in blank-sky observations. The safest conclusion is that S5 0716+714 has $\lesssim$ 2 XTE counts s^{-1} (in 3 PCUs, at the 3σ level) in the 2-10 keV energy band for the duration of the experiment.

S5 0716+714 declined significantly in intensity between planning this multiwavelength campaign and its execution. We had expected RXTE to detect IDV. Our early analysis suggested variability was being detected, and we worked hard with the data to reach conclusions we believe to be reliable. As it is, we are only able to constrain the high-energy tail of S5 0716+714. For example, if we assume a power-law spectrum with $\alpha = 1.9$ as measured from the *ROSAT* data, the RXTE data correspond to a limit on the 2-10 keV flux of $< 8 \times 10^{-12}$ ergs cm^{-2} s^{-1}. This result is only weakly dependent on the assumed spectrum. The result limits the amount of inverse Compton radiation in a hard tail above the synchrotron emission which is dominant at lower energies.

References

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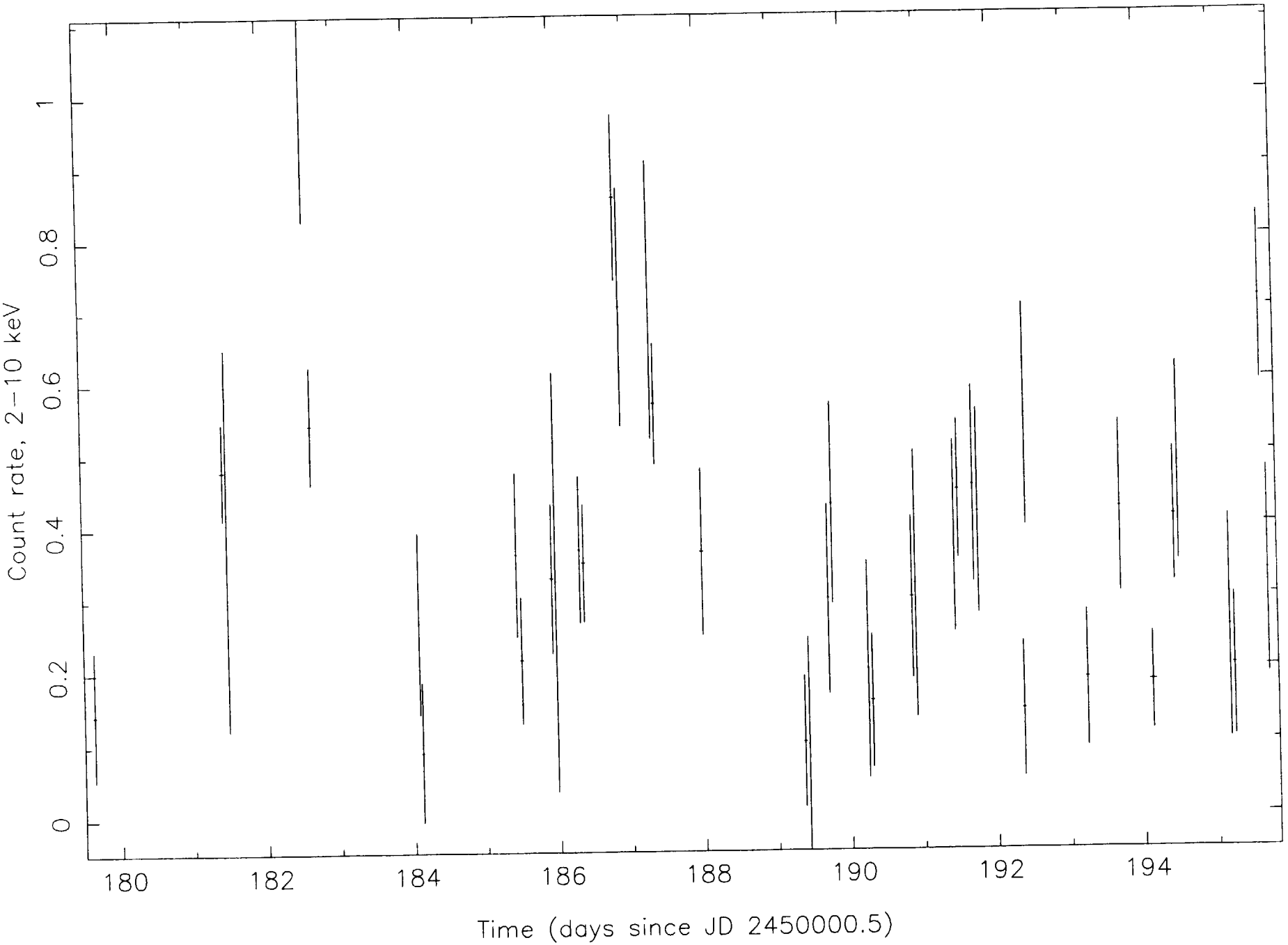
Count rate, 2−10 keV
0
0.2
0.4
0.6
0.8
1
180
182
184
186
188
190
192
194
Time (days since JD 2450000.5)